

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
18 March 2004 (18.03.2004)

PCT

(10) International Publication Number
WO 2004/023825 A1

(51) International Patent Classification⁷: **H04N 13/00**

(21) International Application Number:
PCT/NZ2003/000196

(22) International Filing Date:
4 September 2003 (04.09.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
521177 5 September 2002 (05.09.2002) NZ

(71) Applicant (for all designated States except US): **DEEP VIDEO IMAGING LIMITED** [NZ/NZ]; Airport Road, Mystery Creek, RD 2, 2021 Hamilton (NZ).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **ENGEL, Gabriel, Damon** [US/NZ]; 19a Rostrevor Street, 2001 Hamilton (NZ).

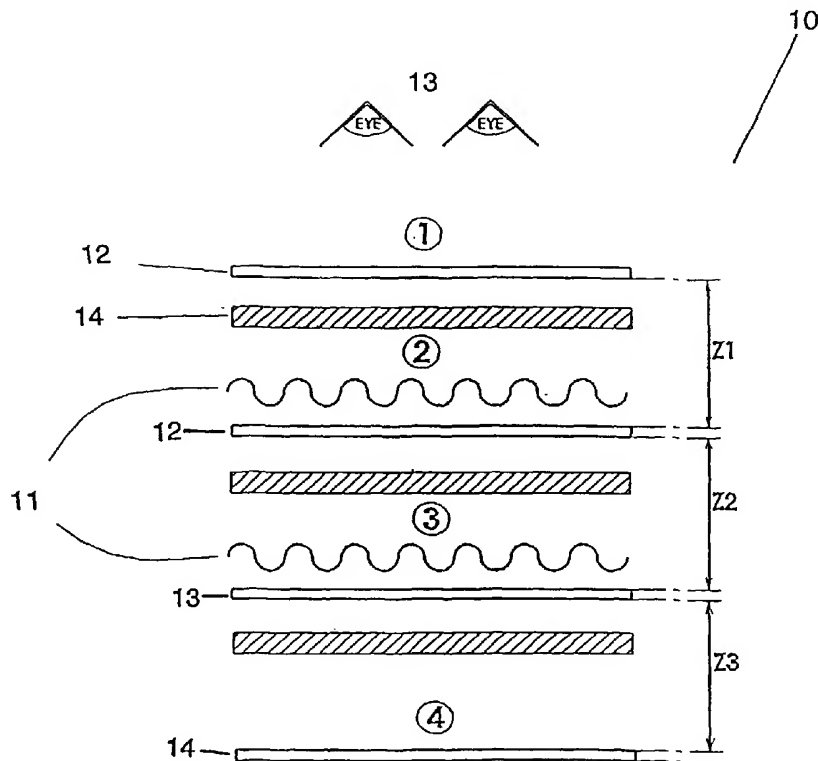
(74) Agents: **MURPHY, Simon** et al.; Private Bag 3140, Level 12, KPMG Centre, 85 Alexandra Street, 2001 Hamilton (NZ).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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(54) Title: AUTOSTEREOSCOPIC IMAGE DISPLAY APPARATUS



(57) Abstract: The present invention relates to an improved imaging system which includes a plurality of display screens located spaced from one another and orientated parallel to one another within the imaging system. The imaging system also includes at least one channelling element positioned in front of at least one of these display screens where the channelling element or elements employed are adapted to provide a view of the imaging system with at least one additional binocular depth cue. A method of operating such an imaging system in addition to display software for such an imaging system is also discussed.

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WO 2004/023825 A1



Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

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AUTOSTEREOSCOPIC IMAGE DISPLAY APPARATUS

TECHNICAL FIELD

This invention relates to an improved imaging system, preferably implemented with or using a multi-layer or multi-screen display. Preferably the present invention may
5 employ at least one light channelling element to provide an observer of the system with a perception of depth within a displayed image.

BACKGROUND ART

Current television and display screen technology in the main consists of single layer screens. These single layer screens can present a two dimensional image for
10 television and movie viewing audiences, or computer screen users (for example.) It would be preferable to have a display system which could present a three dimensional image, or which could present an image to an observer with depth or three dimensional characteristics.

One such system employed to achieve this aim is described in PCT Application No.
15 PCT/NZ00/00143 and its related publication, WO 01/09664. This document describes a multi-layer or multi-screen display constructed from an array of screens displaced from one another with all screens being orientated parallel to each other. Different objects of a scene can then be displayed on an appropriate layer or screen of the display to give the image presented actual depth.

20 The viewer uses a binocular depth cue to calculate the range of an object within a scene through the displaced viewing angle provided by each of the viewers' eyes. The binocular cues provided for objects on a front layer or screen will differ to those given by an object on a rear screen, thereby giving the viewer an indication of depth for each of the objects presented. Furthermore, these multi-screen displays

also exhibit intrinsic motion parallax, where through a viewer changing their viewing angle, there are also appropriate changes in the image they view to again replicate a three dimensional perception of the image.

However, one general limitation found by the applicants with regard to such
5 displays is the discreet nature of each of the layers or screens provided. With most current technology a selection must be made of a particular screen for an object within a scene, where the depth resolution of the final image will be determined by the spacing between each subsequent layer or screen. With current technology there are some limitations with the range of "depth" values which can be assigned
10 to an object. With such technology a maximum bound to the perceivable depth of a scene is set by the actual physical depth of the display system provided.

It would be preferable to have an improved imaging system which could display objects within a screen with a greater range of depth values than those afforded by the system discussed above. It would be preferable to have an improved imaging
15 system which could display an object which appeared to a viewer to be located anywhere within the region bounded by the screens of such a system.

All references, including any patents or patent applications cited in this specification are hereby incorporated by reference. No admission is made that any reference constitutes prior art. The discussion of the references states what their authors
20 assert, and the applicants reserve the right to challenge the accuracy and pertinency of the cited documents. It will be clearly understood that, although a number of prior art publications are referred to herein, this reference does not constitute an admission that any of these documents form part of the common general knowledge in the art, in New Zealand or in any other country.

25 It is an object of the present invention to address the foregoing problems or at least

to provide the public with a useful choice.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

DISCLOSURE OF INVENTION

5 According to one aspect of the present invention there is provided an improved imaging system which includes,

a plurality of display screens located displaced from one another and orientated parallel to one another within the imaging system, and

at least one channelling element positioned in front of at least one of said plurality
10 of display screens,

wherein the said at least one channelling element is adapted to provide a viewer of the imaging system with at least one additional binocular depth cue.

According to a further aspect of the present invention there is provided an improved imaging system substantially as described above wherein a channelling element is
15 provided by at least one lenticular lens.

The present invention is adapted to provide an improved imaging system, preferably which affords a level of depth perception to images presented to a viewer. Such an imaging system may preferably be incorporated within or include a multi-screen display system where objects within an image can be placed on a
20 variety of depth separated screens.

A display screen as used in conjunction with the present invention may be formed from any component, system or technology which can be used to control and subsequently display an image to an observer. Preferably such display screens

may be implemented using technology which has a transparent substrate or backing system so that nests or arrays of display screens may be collected, together displaced from one another, and orientated parallel to one another, to provide or implement an imaging system. Preferably such display screens may be driven
5 through electrical control and data signals to in turn control and change the images presented on such display screens to an observer of the imaging system.

In a preferred embodiment the display screens employed may be provided by liquid crystal displays.

In a further preferred embodiment, active matrix liquid crystal displays using thin
10 film transistors may be employed as display screens.

Reference throughout this specification will also be made to the present invention being implemented with or within a multi-screen display substantially the same as that described in PCT publication WO 01/09664. This type of display system can be used in conjunction with the technology described below to display images
15 which give a viewer a perception of depth for each of the objects presented. However, those skilled in the art should appreciate that other types of existing display systems may also be used in conjunction with the present invention, and reference to the above only throughout this specification should in no way be seen as limiting.

20 Furthermore, reference throughout this specification will also be made to the screens or layers provided by such a displaced system being located displaced from one another and being orientated substantially parallel to one another. Furthermore, the display screens or layers provided will also be referred to as being incorporated or formed from liquid crystal display systems. However, those skilled
25 in the art should appreciate that other forms of display technology such as Organic

Light Emitting Diodes (OLED's), Electroluminesce (EL), and plasma. Each of these technologies can also be used in conjunction with an overlying transmissive (or even transfective) liquid crystal display to achieve a Multi-Layer display configuration. Those skilled in the art should appreciate that references to LCD's
5 only throughout this specification should in no way be seen as limiting.

These types of display systems exhibit some unique information absorption properties for viewers.

The manner in which human beings process visual information has been the subject of extensive and prolonged research in an attempt to understand this
10 complex process. The term pre-attentive processing has been coined to denote the act of the subconscious mind in analysing and processing visual information which has not become the focus of the viewer's conscious awareness.

When viewing a large number of visual elements, certain variations or properties in the visual characteristics of elements can lead to rapid detection by pre-attentive
15 processing. This is significantly faster than requiring a user to individually scan each element, scrutinising for the presence of the said properties. Exactly what properties lend themselves to pre-attentive processing has in itself been the subject of substantial research. Colour, shape, three-dimensional visual clues, orientation, movement and depth have all been investigated to discern the germane visual
20 features that trigger effective pre-attentive processing.

Researchers such as Triesman [1985] conducted experiments using target and boundary detection in an attempt to classify pre-attentive features. Pre-attentive target detection was tested by determining whether a target element was present or absent within a field of background distractor elements. Boundary detection
25 involves attempting to detect the boundary formed by a group of target elements

with a unique visual feature set within distractors. It may be readily visualised for example that a red circle would be immediately discernible set amongst a number of blue circles. Equally, a circle would be readily detectable if set amongst a number of square shaped distractors. In order to test for pre-attentiveness, the number of distractors as seen is varied and if the search time required to identify the targets remains constant, irrespective of the number of distractors, the search is said to be pre-attentive. Similar search time limitations are used to classify boundary detection searches as pre-attentive.

A widespread threshold time used to classify pre-attentiveness is 200-250 msec as this only allows the user opportunity for a single 'look' at a scene. This timeframe is insufficient for a human to consciously decide to look at a different portion of the scene. Search tasks such as those stated above may be accomplished in less than 200 msec, thus suggesting that the information in the display is being processed in parallel unattendedly or pre-attentively.

However, if the target is composed of a conjunction of unique features, i.e. a conjoin search, then research shows that these may not be detected pre-attentively. Using the above examples, if a target is comprised for example, of a red circle set within distractors including blue circles and red squares, it is not possible to detect the red circle pre-attentively as all the distractors include one of the two unique features of the target.

Whilst the above example is based on a relatively simple visual scene, Enns and Rensink [1990] identified that targets given the appearance of being three dimensional objects can also be detected pre-attentively. Thus, for example a target represented by a perspective view of a cube shaded to indicate illumination from above would be pre-attentively detectable amongst a plurality of distractor cubes shaded to imply illumination from a different direction. This illustrates an

important principle in that the relatively complex, high-level concept of perceived three dimensionality may be processed pre-attentively by the sub-conscious mind. In comparison, if the constituent elements of the above described cubes are re-orientated to remove the apparent three dimensionality, subjects cannot pre-attentively detect targets which have been inverted for example. Additional experimentation by Brown et al [1992] confirm that it is the three dimensional orientation characteristic which is pre-attentively detected. Nakaymyama and Silverman [1986] showed that motion and depth were pre-attentive characteristics and that furthermore, stereoscopic depth could be used to overcome the effects of conjoin. This reinforced the work done by Enns Rensink in suggesting that high-level information is conceptually being processed by the low-level visual system of the user. To test the effects of depth, subjects were tasked with detecting targets of different binocular disparity relative to the distractors. Results showed a constant response time irrespective of the increase in distractor numbers.

These experiments were followed by conjoin tasks whereby blue distractors were placed on a front plane whilst red distractors were located on a rear plane and the target was either red on the front plane or blue on the rear plane for stereo colour (SC) conjoin tests, whilst stereo and motion (SM) trials utilised distractors on the front plane moving up or on the back plane moving down with a target on either the front plane moving down or on the back plane moving up.

Results showed the response time for SC and SM trials were constant and below the 250 msec threshold regardless of the number of distractors. The trials involved conjoin as the target did not possess a feature unique to all the distractors. However, it appeared the observers were able to search each plane pre-attentively in turn without interference from distractors in another plane.

This research was further reinforced by Melton and Scharff [1998] in a series of experiments in which a search task consisting of locating an intermediate-sized target amongst large and small distractors tested the serial nature of the search whereby the target was embedded in the same plane as the distractors and the
5 pre-attentive nature of the search whereby the target was placed in a separate depth plane to the distractors.

The relative influence of the total number of distractors present (regardless of their depth) verses the number of distractors present solely in the depth plane of the target was also investigated. The results showed a number of interesting features
10 including the significant modification of the response time resulting from the target presence or absence. In the target absence trials, the reaction times of all the subjects displayed a direct correspondence to the number of distractors whilst the target present trials did not display any such dependency. Furthermore, it was found that the reaction times in instances where distractors were spread across
15 multiple depths were faster than for distractors located in a single depth plane.

Consequently, the use of a plurality of depth/focal planes as a means of displaying information can enhance pre-attentive processing with enhanced reaction/assimilation times.

These types of display systems also preferably incorporate multiple liquid crystal
20 displays. However, as discussed previously, those skilled in the art should appreciate that other types of display technology including but not limited to OLED type displays or other forms of display technology which provide a transparent display substrate may also used if required.

There are two main types of Liquid Crystal Displays used in computer monitors,
25 passive matrix and active matrix. Passive-matrix Liquid Crystal Displays use a

simple grid to supply electrical charge to a particular pixel on the display. The grids made from a transparent conductive material (usually indium tin oxide), are formed using two glass layers called substrates, one provided with columns, the other with rows.

- 5 The rows or columns are connected to integrated circuits that control when a charge is applied to a particular column or row. The liquid crystal material is sandwiched between the two glass substrates, and a polarising film is added to the outer side of each substrate.

A pixel is defined as the smallest resolvable area of an image, either on a screen or
10 stored in memory. Each pixel in a monochrome image has its own brightness, from 0 for black to the maximum value (e.g. 255 for an eight-bit pixel) for white. In a colour image, each pixel has its own brightness and colour, usually represented as a combination of red, green and blue intensities.

To activate a particular pixel, the integrated circuit applies a charge to the relevant
15 column of one substrate whilst grounding the corresponding row on the other substrate. The voltage applied to the intersection of the relevant row and column designating the pixel untwists the liquid crystals at that pixel.

However, the passive matrix system has significant drawbacks, notably slow response time and imprecise voltage control. Response time refers to the Liquid
20 Crystal Displays ability to refresh the image displayed. Imprecise voltage control hinders the passive matrix's ability to influence a single pixel at a time. When voltage is applied to untwist one pixel, the pixels around it also partially untwist, which makes images appear fuzzy and lacking in contrast.

Active-matrix Liquid Crystal Displays depend on thin film transistors (TFT). Thin
25 film transistors are tiny switching transistors and capacitors arranged in a matrix on

a glass substrate. To address a particular pixel, the appropriate row is switched on, and then a charge is sent down the correct column. Since all of the other rows that the column intersects are turned off, only the capacitor at the designated pixel receives a charge. The capacitor is able to hold the charge until the next refresh
5 cycle. Furthermore, if the amount of voltage supplied to the crystal is carefully controlled, it can be made to untwist only enough to allow some light through. By doing this in very exact, very small increments, Liquid Crystal Displays can create a grey scale. Most displays today offer 256 levels of brightness per pixel.

A Liquid Crystal Display that can show colours must have three subpixels with red,
10 green and blue colour filters to create each colour pixel. Through the careful control and variation of the voltage applied, the intensity of each subpixel can range over 256 shades. Combining the subpixels produces a possible palette of 16.8 million colours (256 shades of red x 256 shades of green x 256 shades of blue).

Liquid Crystal Displays employ several variations of liquid crystal technology,
15 including super twisted nematics, dual scan twisted nematics, ferroelectric liquid crystal and surface stabilized ferroelectric liquid crystal. There are also emissive technologies such as Organic Light Emitting Diodes which are addressed in the same manner as Liquid Crystal Displays.

Preferably the present invention includes at least one channelling element which is
20 adapted to vary the appearance of the image presented depending on a viewer or observer's viewing angle. In this way a channelling element can be used to present varying images to each of an observer's eyes.

A channelling element as referred to throughout this specification may be defined
as any component, element or apparatus which is adapted to modify or block the
25 path of light emitted from or reflected by an object. Preferably the channelling

element used in accordance with preferred embodiments may be formed from refractive components or lenses, but in other instances may also consist of elements which simply act to block light from an image or object.

Such a channelling element or elements may give the viewer an additional
5 binocular depth cue which the viewer uses to calculate the distance from the object displayed. This binocular disparity provides a depth cue which can be used to vary the content displayed. As the viewer's eyes are displaced from one another, they view an image from slightly different angles, and the brain in turn processes both images to calculate a distance or range for the object in question. A channelling
10 element or elements can be used to present varying images to each of the observer's eyes, giving the impression that an object is not actually displayed on one of the screens provided within the imaging system. This provides a level of depth perception to the images presented with the system's display screens.

A depth cue provides a binocular disparity to the viewer, which in turn is used to
15 vary the content displayed using the present invention. The disparity between views presented to the left and right eyes of an observer can be used to provide the appearance of a three dimensional image or effect within content displayed.

For example, a single object may be displayed which appears to have a true three dimensional character to an observer. An object, such as for example a pool cue
20 can be made to appear so as to start behind a particular screen, and to protrude through the screen to finish in front of the screen.

In a preferred embodiment a single channelling element may be located in front of a screen incorporated into the imaging system. The channelling element may in turn vary or alter the path of light emitted from the screen behind it to present a
25 variable image to each of an observer's eyes. This configuration of the invention

will allow images to be presented which contain objects appearing to be behind the screen on which they are displayed. This allows objects within a scene to be positioned at a wide number or range of depth locations by the imaging system.

5 In a further preferred embodiment a degree of variation or variability may be provided with respect to the positioning of a channelling element or elements within the imaging system provided. Some screens incorporated into the imaging system may have a channelling element provided in front of same whereas other screens may not. The present invention may encompass embodiments where each and every screen includes a channelling element in front of same, to other
10 embodiments where only a single screen of the imaging system is provided with a channelling element located in front of same. Those skilled in the art should appreciate that various configurations of the numbers of channelling elements being provided in front of the screens of an imaging system are within the scope of the present invention.

15 In a further preferred embodiment a channelling element may be formed from a lenticular lens or lenses. A lenticular lens, as discussed throughout this specification, may consist of or incorporate a series of semi-circular cylindrical lenses moulded or attached to a flat backing or substrate. The flat backing the lens can be presented to the display screen involved to allow light from the image it
20 displays to exit from the opposite curved edges or faces of the cylindrical portions of the lens. Such 'lenticular sheets' will also be referred to as lenticular lens throughout this specification.

Reference throughout this specification will also be made to a lenticular lens being employed as a channelling element required for the present invention. However,
25 those skilled in the art should appreciate that other configurations of the invention which do not necessarily require lenticular lenses are envisioned, and reference to

the above only throughout this specification should in no way be seen as limiting. For example, in one alternative embodiment a parallax barrier may be employed, which consists of a fine vertical grating placed in front of an image. Each of the adjacent bars of the grating will block certain sections of the image depending on the viewing angle involved, thereby presenting an alternate image to each eye of the viewer.

Preferably one channelling element or lenticular lens arrangement only may be provided for a screen of the imaging system. A single lens can be employed to adjust the images presented at various viewing angles by the imaging system.

10 In such an embodiment a series of lenticular lenses or other similar channelling elements may be provided to form a relatively compact display apparatus or imaging system. Normally with the multi-screen or multi-layer apparatus similar to those discussed with respect to PCT Publication No. WO 01/09664, an air gap or space is provided between each screen of the display. However, with the provision of channelling elements as discussed above, this air gap or free space may be replaced or reduced with a thin channelling element. A channelling element can in turn give an observer binocular depth cues similar to those obtained through using an air gap or space between adjacent screens.

20 In a preferred embodiment a channelling element placed in front of a display screen may be directly connected to the display screen involved. This will provide an improved imaging system wherein a channelling element is directly connected to the front surface of a display screen to form an integral assembly. Preferably an adhesive or lacquering system may be used to connect or attach a channelling element to the front surface of the display screen in a preferred embodiment to implement the integral assembly required.

However, a channelling element or lenticular lens need not necessarily be provided in front of each and every screen incorporated into the imaging system in other embodiments. In such embodiments, a lower number of channelling elements than displays may be incorporated into the imaging system. Some screens may be provided without an associated lenticular lens if required. Those skilled in the art should appreciate that other forms of channelling elements may also be employed in conjunction with the present invention, and other configurations of multi-layered displays which do not employ a channelling element before each and every screen or layer may also be provided in conjunction with the present invention.

For example, in one alternative embodiment a lenticular lens or lenses may not be employed as discussed above. The images to be displayed using such an imaging system may be formed from an array of separate two dimensional 'source' images. Each source image may be taken from a particular viewpoint where an observer's eyes are likely to sit at, where two or potentially more 'source' images may be incorporated if the observer is expected to view the resultant image from a number of positions. These source images can be divided into a number of vertically orientated strips and interleaved or interlaced with one another to provide the resultant image to be displayed. These types of channelling elements can be described as parallel barriers. Some lateral compression of this resulting image may also be completed to ensure that the final resultant image can be displayed in its entirety on a single screen.

Reference throughout this specification will also be made to a channelling element being formed from a lenticular lens, series of a lenticular lens or a lenticular sheet including a plurality of lenticular lenses. However, those skilled in the art should appreciate that other types of channelling element which can preferably be used to present alternative images to an observer depending on the observer's viewing

angle, may also be employed as channelling elements if required in conjunction with the present invention.

In a preferred embodiment the imaging system provided may also include features or components adapted to eliminate optical moire interference patterns from being
5 viewed by an observer of the system. These interference patterns can be formed by repetitious patterns in the substrate and pixel alignment layers of a display screen interfering with similar repetitious structures provided in a lenticular lens placed in front of the display screen involved.

In a further preferred embodiment an optical diffusing element may be placed in
10 front of a lenticular lens or any other channelling element within the imaging system provided. Such a diffuser may break up any interference patterns formed to prevent same from being seen by an observer of the system.

However, in other alternative embodiments, different mechanisms or design implementations may be employed to avoid the observation of such interference
15 patterns. For example, in one alternative embodiment the pixel alignment structures or elements of a display or any other components of same with a repetitious structure may be angled or shifted from their standard alignment pattern. Furthermore, anti-interference pixel patterns may also be employed to break up such repetitious structures which cause interference patterns. Similar anti-
20 interference techniques to that disclosed in Patent Co-Operation Treaty Application No. PCT/NZ03/00153 may also be employed if required in conjunction with the present invention.

In some embodiments of the present invention a lenticular lens or channelling element may not necessarily extend across the entire face or front surface of a
25 display screen. In such embodiments a portion only of a display screen may be

covered by a lenticular lens, thereby allowing the display screen to present or display a combination of both the stereoscopic and 2-dimensional images if required. Furthermore, any arrangement or combination of such "partial" lenticular lenses or channelling elements which cover a portion only of the display screen
5 may be used in conjunction with the present invention (with full coverage channelling elements for example), if required.

According to one aspect of the present invention there is provided a method of operating an imaging system substantially as described above characterised by the steps of:

- 10 (i) displaying stereoscopic images using a display screen which has a channelling element located in front of and adjacent to said display screen, and
- (ii) displaying 2-dimensional images using a display screen which does not have a channelling element located in front of and adjacent to said display screen.

15 According to a further aspect of the present invention there is provided display software adapted to facilitate the display of images using an imaging system substantially as described above, said display software being adapted to execute the steps of:

- 20 (i) transmitting image data to display components of a display screen, said display screen having a channelling element located in front of and adjacent to said display screen, said image data being used by said display components to display a stereoscopic image using said display screen, and
- (ii) transmitting image data to display components of a display screen which does not have a channelling element located in front of and adjacent to said

display screen, said image data being used by said display components to display a 2-dimensional image using said display screen.

Preferably the present invention also encompasses a method of operating an imaging system substantially as described above, and also display software
5 adapted to implement such a method of operation. In such cases, the present invention allows for the presentation of both 2-dimensional and stereoscopic based images. Preferably display software may be used to format image data for presentation on a particular display screen of an imaging system where the characteristics of each display screen and their proximity to a channelling element
10 will determine the type, format or characteristics of the imaging data supplied.

In a preferred embodiment each display screen may include display components adapted to receive data signals or information and in turn to control the actual presentation or display of images on a display screen. Those skilled in the art should appreciate that well known electrical display driver components may be
15 employed in conjunction with the present invention to implement such display components which are adapted to receive appropriate image data for the display screen.

In a preferred embodiment the display software provided may transmit different image data depending on whether a stereoscopic type image or 2-dimensional type
20 image is to be displayed on at least a portion of the display screen. Those skilled in the art should appreciate standard display processing techniques and systems may be used to provide or transmit image data for 2-dimensional images. However, with stereoscopic images which provide or include an additional binocular depth cue to an observer, further processing or modification of standard image data may
25 be required to facilitate the presentation of an intelligible stereoscopic image. Those skilled in the art should also appreciate that the particular form or

configuration of the channelling element provided in conjunction with a display screen used to present such a stereoscopic image will in turn determine the format or processing employed in conjunction with such image data.

The present invention may provide many potential advantages over the prior art.

- 5 The use of a lenticular lens or lenses, or any functionally equivalent device may allow objects within a scene to be presented to a viewer as if they were located in the spaces between the multiple screens of the imaging system. The entire depth of the imaging system can then be employed to present a scene, and objects within a scene are not limited to being displayed directly on one of the screens provided.
- 10 Furthermore, the images displayed not necessarily suffer from parallax errors as the viewer changing the viewing angle will in turn be compensated for by the use of a lenticular lens or other similar device.

- The present invention may also be employed to extend or increase an observer's perception of depth past the physical or actual depth of the display or imaging system provided. Through the use of a channelling element or elements images
- 15 can be presented which appear to an observer to reside past or have a depth greater than the physical depth of the imaging system.

- Furthermore, the present invention may also be adapted to facilitate the ready integration or display of standard "2-dimensional" images in addition to images
- 20 which appear to have depth or provide a stereoscopic effect through use of a channelling element. Stereoscopic and 2-dimensional (2D) images can be displayed in a single scene to an observer relatively easily using any required combination of configuration of one or more channelling elements in accordance with the present invention.

For example, in one preferred embodiment a channelling element may be located in front of a screen located to the rear of an imaging system while a display screen to the front of the imaging system is not provided with a channelling element in front of same. This will allow stereoscopic images of objects to be displayed in conjunction with the rearward screen for example, while image manipulation tools or icons presented in two dimensions only may be displayed in conjunction with the forward screen (which lacks an associated channelling element). Furthermore, any required configuration or combination of channelling elements in front of display screens may also be implemented to reverse the order of the previous example, or alternatively to provide or display stereoscopic images using all display screens where channelling elements are located in front of all display screens if required.

BRIEF DESCRIPTION OF DRAWINGS

Further aspects of the present invention will become apparent from the following description which is given by way of example only and with reference to the accompanying drawings in which:

Figure 1a - 1b show the use of a lenticular lens displaying variable images to offset viewing angles, and

Figure 2 shows a composite image viewed through a lenticular lens, and

Figure 3 shows a process executed to construct a composite image to be displayed behind a lenticular lens, and

Figure 4 shows a schematic view of the construction and arrangement of an improved imaging system formed in accordance with the preferred embodiment of the present invention, and

Figure 5a – 5f show schematic views of the construction and arrangement of imaging systems configured in accordance with further embodiments of the present invention.

BEST MODES FOR CARRYING OUT THE INVENTION

- 5 Figures 1a and 1b show the use of a lenticular lens (1) to display variable images to offset viewing angles.

The lens (1) is placed in front of a screen or display media (2) which shows separate portions A and B of an image. The eyes of an observer (3) can be orientated at different angles as shown with respect to figures 1A and 1B.

- 10 When the screen (2) is viewed from the orientation shown with respect to figure 1, the A portions only of the image are visible. Conversely where the viewing position is offset to that shown with respect to figure 1b, the B portions only of the same image are visible to the observer.

- 15 This characteristic of lenticular lenses is further illustrated in figure 2. Again the same composite image A, B is shown on the screen (2) which is behind the lenticular lens (1).

- 20 Due to the light refracting effects of the lens (1) the left eye will only observe portion A of the image displayed, whereas the right eye will only view portion B of the same image. The selected portions A,B can be formed so as to provide an additional binocular depth cue to the observer which the observer uses to calculate or estimate their range from the object or image displayed. The portions of the image A,B can be manipulated and configured so as to make the observer believe that the object displayed in fact appears in front of or behind the screen (2), instead of on the screen.

Figure 3 shows how such composite image portions can be assembled together to provide the image to be displayed.

In the embodiment shown with respect to figure 3 an image of a cube is to be displayed. Two separate source images or pictures can be recorded to give the
5 view which is to be presented to each of the left and right eyes of the observer.

Each of the two source images recorded are then divided into a series of vertical strips which are consecutively interlaced with one another to provide the final composite image to be displayed behind a lenticular lens. This composite final image, when viewed from behind the lenticular lens, will appear to the observer to
10 originate behind the display screen in which it is presented, and to have actual depth or three dimensional qualities.

Figure 4 shows a schematic diagram of the construction and arrangement of an improved imaging system (10) formed in accordance with the preferred embodiment to the present invention.

15 The imaging system (10) incorporates a plurality of display screens, formed in this embodiment by four separate liquid crystal display screens (12). In front of the second and third screens (12) is provided a single channelling element, formed in this embodiment by lenticular lenses (11). Also positioned between each adjacent screen (12) is a refractor (14) used to alleviate parallax errors which can be viewed
20 at the edges of the imaging system, and to prevent the viewer seeing beyond the edges of a rear screen. However, those skilled in the art should also appreciate that the provision of a refractor (14) as discussed in the specific embodiment listed by way of example only, should in no way be considered to be essential to the implementation of the present invention.

25 The eyes of an observer (13) will view the objects presented within images

displayed on each of the display screens (12). The second and third screens of the system will display composite interleaved images which take advantage of the lenticular lenses (11) provided. The composite images formed can make some or all of the objects they displayed appear to the viewer to reside within the open
5 spaces between each display screen separated by distances Z2 or Z3.

Those skilled in the art should also appreciate that the displacements Z2, Z3 between the screens shown need not necessarily be considered essential as in other embodiments a relatively compact system may be provided through use of lenticular lenses (11) only to give the binocular depth cues required.

10 The composite image displayed may be formed from a series of images of the same scene displaced over a range of viewing angles. These source images can then be interleaved with one another for the display of an image, which gives a viewer another binocular depth cue due to the differing images being presented to the left and right eyes of the viewer. The additional depth cue, or depth information
15 provided can then make the objects within such an image appear to be displaced from the actual display screen provided.

Figures 5a through 5f show the construction and arrangement of imaging systems configured in accordance with further embodiments of the present invention.

Figures 5a through 5f show schematic views of imaging systems which include a
20 front display screen (12a) and a rear display screen (12b). As discussed with respect to other embodiments of the present invention liquid crystal display technology may be used to provide such display screens (12).

The imaging system provided in the embodiments shown also includes at least one channelling element (11), formed in these embodiments by the provision of a sheet
25 of lenticular lenses disposed in front of at least one display screen (12).

In the embodiment shown with respect to figure 5a, a lenticular lens assembly is provided in front of both the front and rear screens (12a, 12b). This allows a stereoscopic images to be presented on both display screens provided.

Conversely, in the embodiment shown with respect to figure 5b, a single lenticular lens assembly (11) is provided in front of the rear display screen (12b). This implementation allows 2-dimensional images (such as toolbars and so forth for computer displays) to be presented on a front screen (12a) while a stereoscopic image or images can be displayed on a rear screen (12b).

Figure 5c shows the inverse arrangement of that discussed with respect to figure 5b. In this embodiment stereoscopic images can be presented on the front screen (12a) while 2-dimensional images are shown on the rear screen (12b).

Figures 5d and 5e show implementations of an imaging system which includes design features employed to combat the observation or moire interference patterns by an observer of the system. In both the cases shown, a diffuser (15) is provided to break up or disperse the regular pixel alignment patterns present in the rear screen (12b) which can cause interference patterns when viewed through the lenticular lens (11) shown. The diffuser (15) provided can be used to break up the optical effects of such regular patterned components to in turn prevent moire interference patterns from being observed.

Figure 5f shows yet another alternative configuration of an imaging system. In the situation shown a lenticular lens assembly (11) is provided in front of each of the front and rear display screens (12a, 12b). However, the lens system provided extends only over a portion of each display screen thereby allowing for the presentation of stereoscopic images on the covered portion only of the display screens. Conversely, 2-dimensional images may be displayed on the uncovered

section of each display if required.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof as defined in the appended claims.

WHAT WE CLAIM IS:

1. An improved imaging system which includes

a plurality of display screens located displaced from one another and orientated parallel to one another within the imaging system, and

at least one channelling element positioned in front of at least one of said plurality of display screens

wherein the said at least one channelling element is adapted to provide a view of the imaging system with at least one additional binocular depth cue.
2. An improved imaging system as claimed in claim 1 wherein a depth cue provides a binocular disparity to the viewer to vary the content displayed.
3. An improved imaging system as claimed in claim 1 wherein a channelling element is used to present varying images to each of an observer's eyes.
4. An improved imaging system as claimed in claim 2 or 3 wherein disparity between views presented to left and right eyes of observers provides a level depth perception to images presented.
5. An improved imaging system as claimed in any previous claim wherein a channelling element is adapted to modify the path of light emitted from or reflected by a surface.
6. An improved imaging system as claimed in any previous claim wherein a channelling element is used to reduce free space between display screens.

7. An improved imaging system as claimed in any previous claim wherein a channelling element is directly connected to the front surface of a display screen to form an integral assembly.
8. An improved imaging system as claimed in any previous claim which includes a single channelling element for each display screen of the imaging system.
9. An improved imaging system as claimed in any one of claims 1 to 7 wherein the imaging system includes a lower number of channelling elements than display screens.
10. An improved imaging system as claimed in any previous claim wherein a channelling element is provided by a lenticular lens or lenses.
11. An improved imaging system as claimed in any one of claims 1 to 9 wherein a channelling element is formed from a parallax barrier.
12. An improved imaging system as claimed in any previous claim wherein liquid crystal displays are used to provide display screens.
13. An improved imaging system as claimed in claim 12 wherein active matrix liquid crystal displays using thin film transistors are used to provide display screens.
14. A method of operating an imaging system characterised by the steps of:
 - (i) displaying stereoscopic images using a display screen which has a channelling element located in front of and adjacent to said display screen, and
 - (ii) displaying 2-dimensional images using a display screen which does not have a channelling element located in front of and adjacent to said

display screen.

15. Display software adapted to facilitate the display of images using the imaging system, said display software being adapted to execute the steps of:
 - (i) transmitting image data to display components of a display screen, said display screen having a channelling element located in front of and adjacent to said display screen, said image data being used by said display components to display a stereoscopic image using said display screen, and
 - (ii) transmitting image data to display components of a display screen which does not have a channelling element located in front of and adjacent to said display screen, said image data being used by said display components to display a 2-dimensional image using said display screen.
16. An improved imaging system substantially as herein described with reference to and as illustrated by the accompanying drawings and/or examples.
17. A method of manufacturing an improved imaging system substantially as herein described with reference to and as illustrated by the accompanying drawings and/or examples.
18. Display software substantially as herein described above with reference to and as illustrated by the accompanying examples.
19. A method of operating an imaging system substantially as herein described with reference to and as illustrated by the accompanying drawings and/or examples.

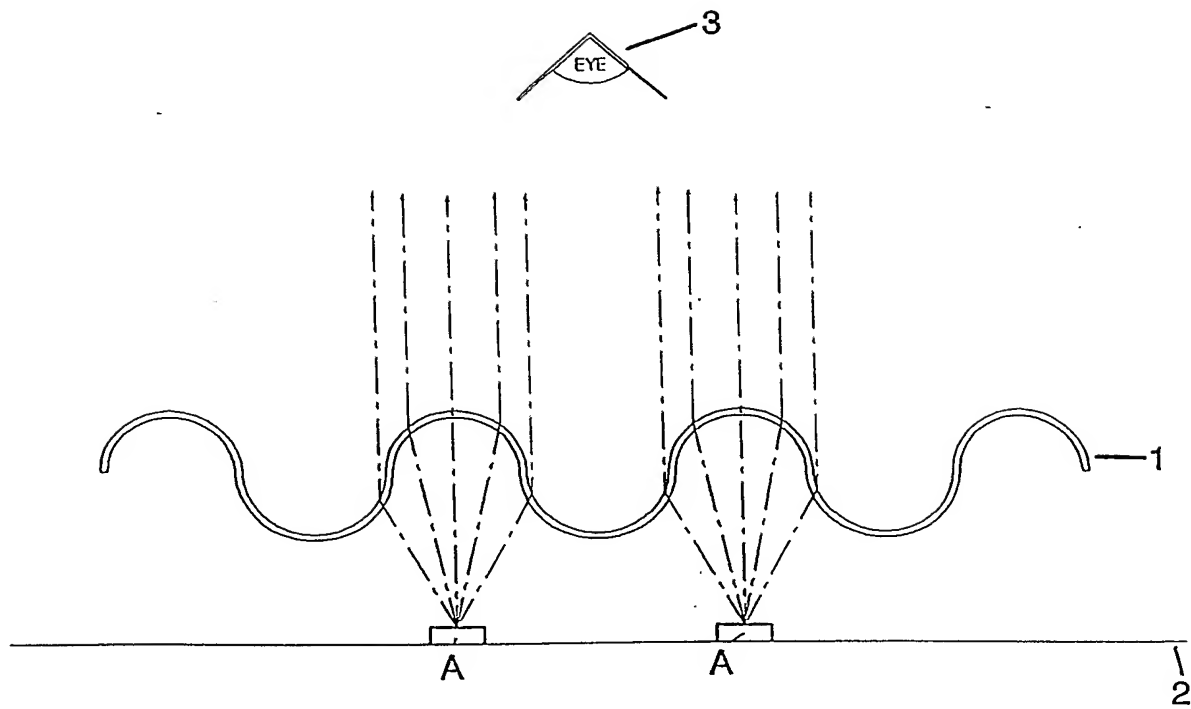
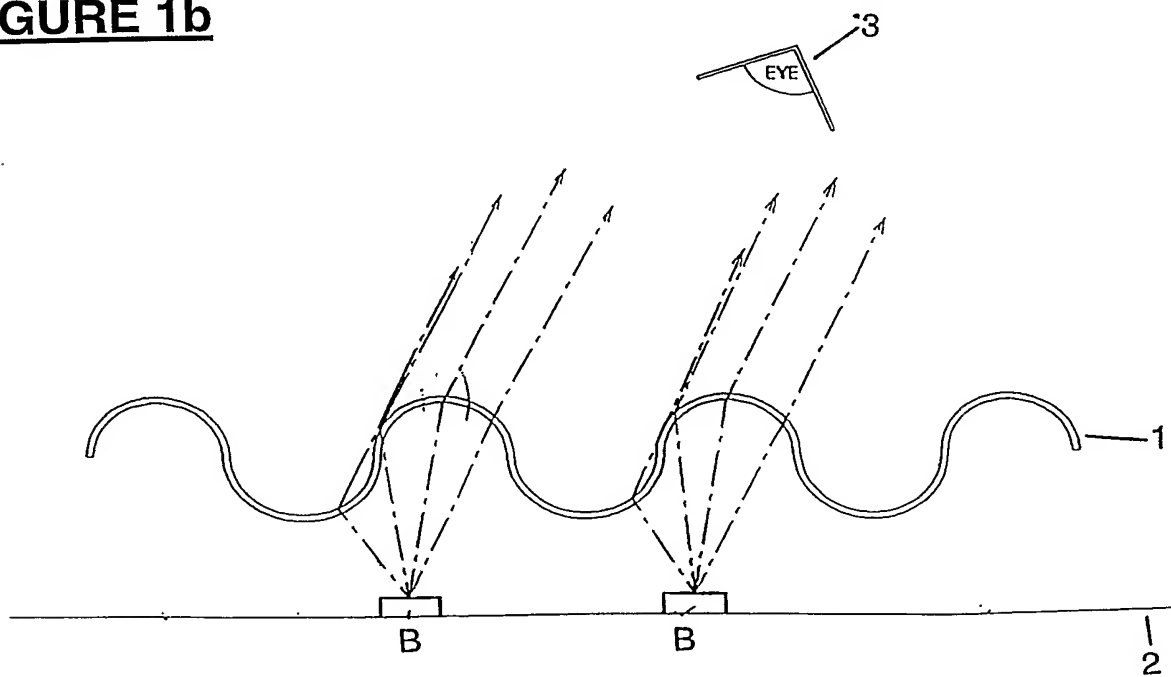
FIGURE 1a**FIGURE 1b**

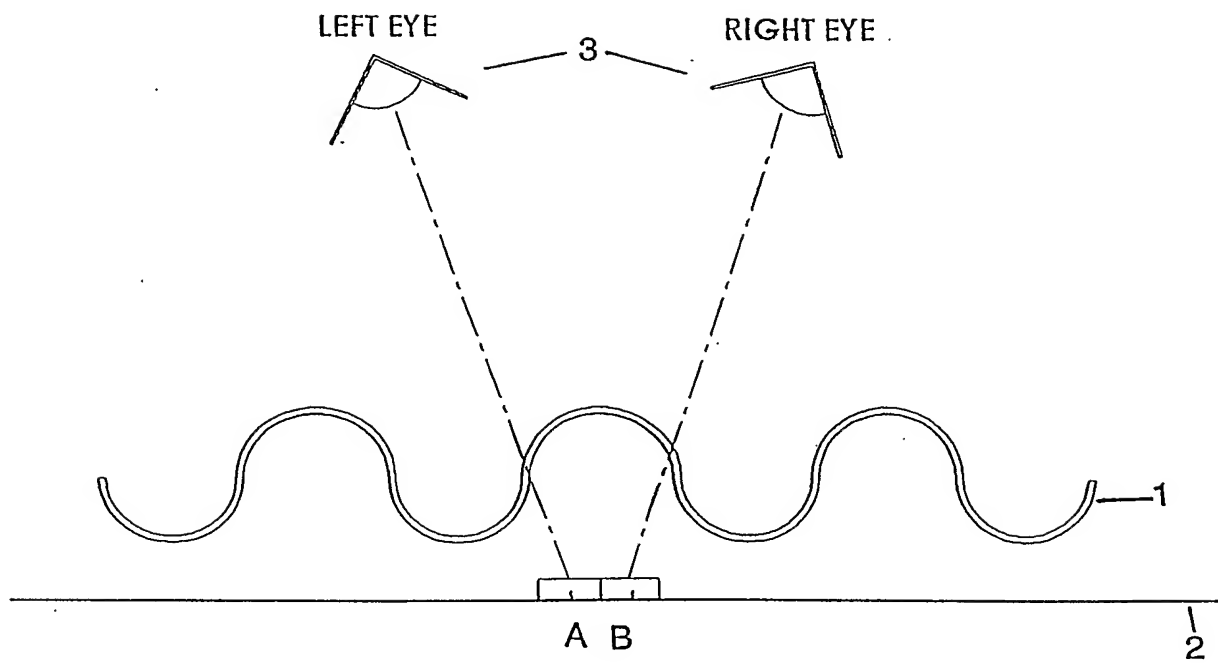
FIGURE 2

FIGURE 3

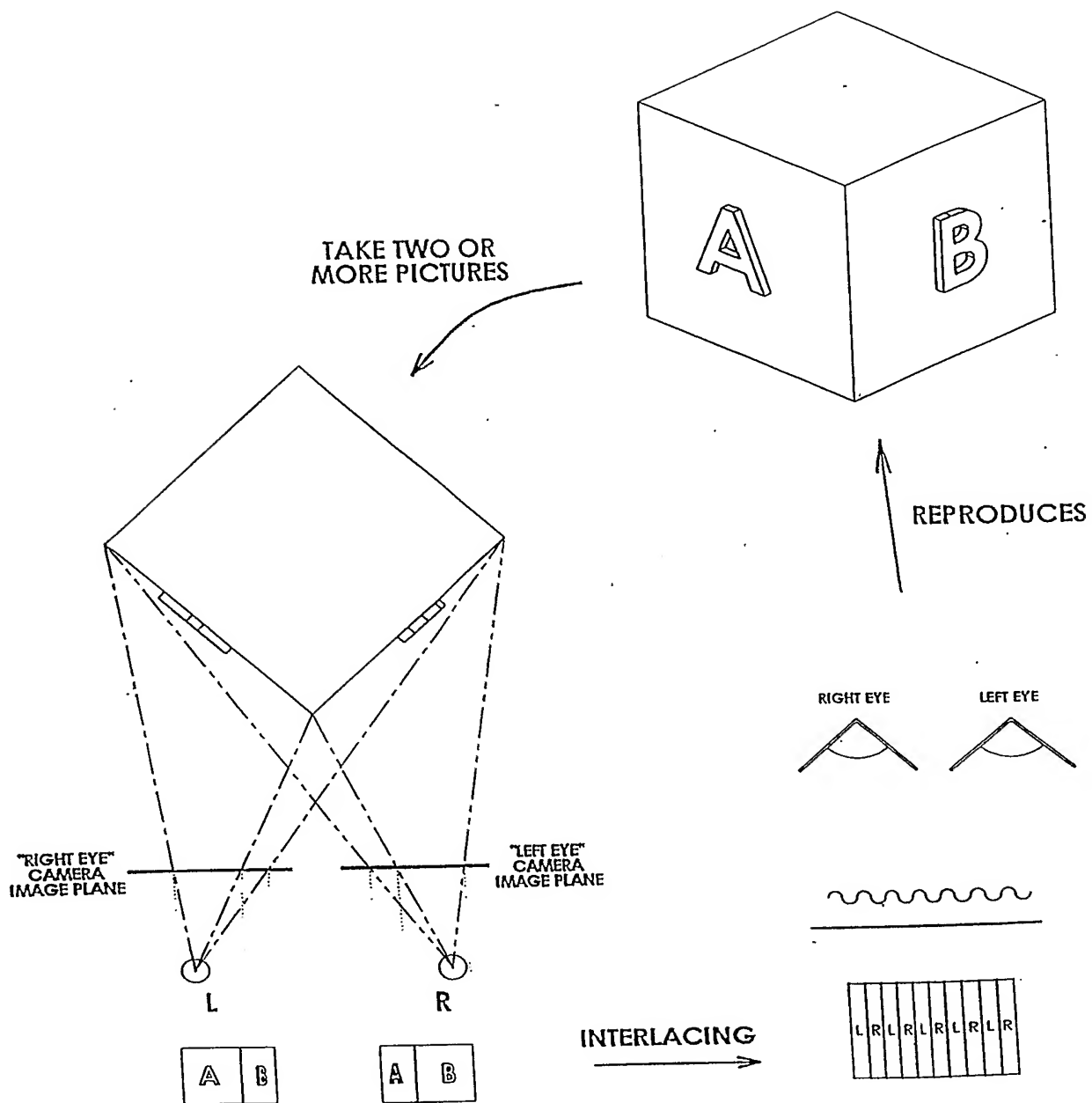


FIGURE 4

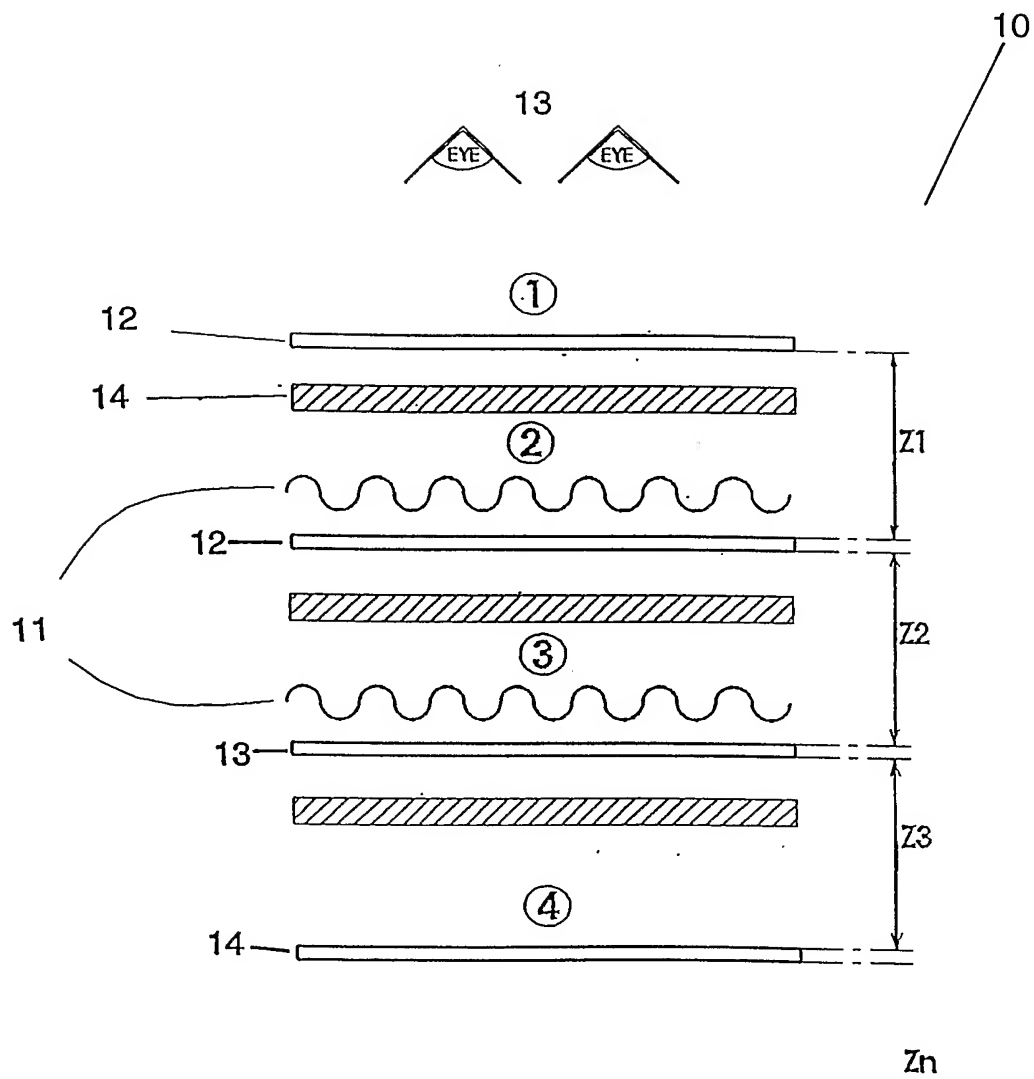


FIGURE 5a

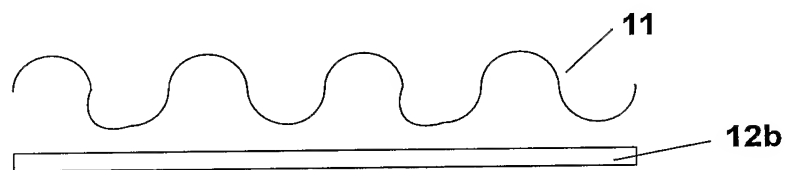
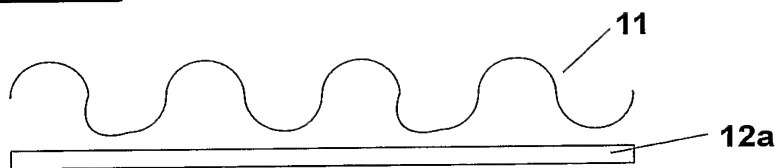


FIGURE 5b

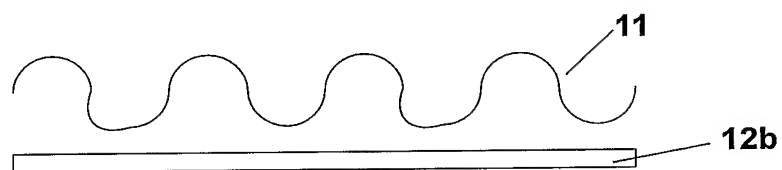


FIGURE 5c

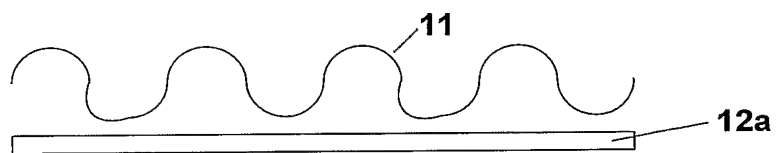
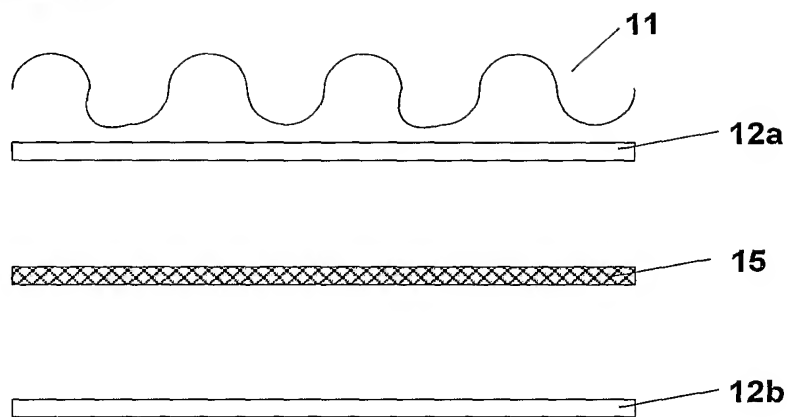
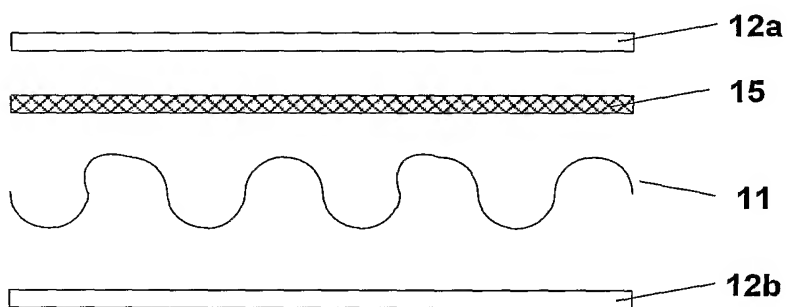
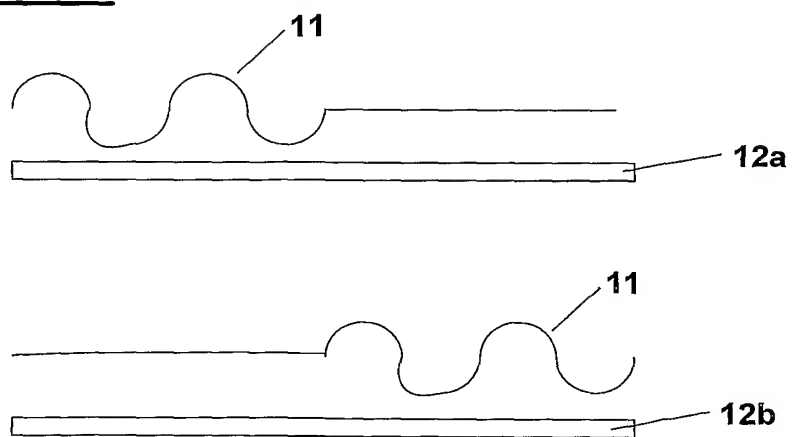


FIGURE 5d**FIGURE 5e****FIGURE 5f**

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NZ 03/00196

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N13/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 02 05014 A (STREET GRAHAM S B) 17 January 2002 (2002-01-17) figure 2A page 13, line 13 - line 23; claim 23 ---	1-5, 7-12, 14-19
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☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

16 January 2004

Date of mailing of the international search report

26/01/2004

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

De Paepe, W

INTERNATIONAL SEARCH REPORT

information on patent family members

Intel
al Application No
PCT/NZ 03/00196

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